

WORST CASE ANALYSIS PARTS DATA BASE

Project	SEAWINDS		
SER P/N	2N2222A	PART TYPE	TRANSISTOR
SOURCE P/N	ANS2N2222A	DESCRIPTION	General Purpose NPN
HIGH TEMP	85°C	CASE	
LOW TEMP		CASE	
IFE	5 Years		
RADIATION	10K RAD		
JPL D-8545			
Maximum Ratings	Max	derating	Min
VCEO	40	30	v
VEBO	6	4.s	v
ICmax	800	600	mA
FT	326.25		MHz.
Total Device Dissipation	1200	364.6	mW
Junction Temperature	200	110	c
These parameters are necessary to derive the SPICE models			
	Max	Nom	Min
High Current 50% hFE max	452	235.1267	16.50
Low Current 50% IH	150	150	150 mA
VSat VCE sat	1.206	0.746324564	0.291V v
@ IC	500	500	mA
VBE On VBE	1.374V	0.9	0.426V V
@ IC	1	1	mA
Storage Time Ts	247.5	225.00	202.5 nS
Gain Bandwidth Product Ft	326.25	301.40625	276.5625 MHz
Output Capacitance COB	6.4	5.532	pF
@ VCB	10	10	v
Input Capacitance CIB	26.25	16.68753563	7.125071 pF
@ VEB	0.5	0.5	V
Parameter			
VCE (sat)	Max	Min	Source
VCE (Sat)@ 500 mA	1.000	0.300	Figure 3 of Motorola data book DL126 Rev3, pg 3-21
Aging 15%@3 yra	0.194	0.000	Arrhenius equation approximation and JPL D 5703 pg B
Temperature	0.012	-0.009	JPL D-5703 pg B-8
Radiation	0.000	0.000	data from ESA suggests no appreciable change
Worst Case Total	1.206	0.291	
Worst Case Max = 1.206V	Worst Case Min = 0.291V		
Parameter			
VBE (sat)	MAX	MIN	Source
VBE (Sat) nominal@ IC of .5 to 500 mA	0.900	0.900	Motorola data book DL126 Rev3, pg 3-19
initial tolerance	0.300	-0.300	Motorola data book DL126 Rev3, pg 3-19
Aging 15%@3 yra	0.174	-0.174	JPL D-5703 pg B-26
Temperature	0.000	0.000	included in aging per JPL D 5703
Radiation	0.000	0.000	data from ESA suggests no appreciable change
Worst Case Total	1.374	0.426	v
Worst Case Max = 1.374V	Worst Case Min = 0.426V		
(Continued)			

USER P/N	2N2222A	PART TYPE	TRANSISTOR
SOURCE P/N	ANS2N2222A	DESCRIPTION	General Purpose NPN
		VALUE RANGE	0 - 500 mW, 0 to 600 mA
Parameter			
ICBO			Source
25C rated value	0.01	μA	from MIL-SPEC
Aging 50% over 3 yrs	0.006	μA	from JPL D-5703 & arrenhius approx adjustment for life>
radiation	0.000	μA	ESA data indicates relatively no change
Temp Multiplier = $2/10^{\circ}\text{C}$	0.120	μA	JPL D5703, multiply spec value by 2 for every 10C above
0.136 μA@85°C			
Parameter			
IEBO			Source
25C rated value	0.010	μA	from MIL-SPEC
Aging 50% over 3 yrs	0.006	μA	from JPL D-5703 & arrenhius approx adjustment for life>
radiation	0.000	μA	ESA data indicates relatively no change
Temp Multiplier = $2/10^{\circ}\text{C}$	4.800	μA	JPL D5703, multiply spec value by 2 for every 10C above
4.816 μA@85°C			
Parameter			
T-Gain Bandwidth	Plot# Product	Spec @ 25 °C VCE=	20V f=100MHz
			Source
minimum	300.000		MHz. Motorola data book DL 126 rev 3, pg 3-34
Pos Bias	Neg		Random
High Temp variation @85°C	0.00%	3.75%	0.00% Max per JPL D-5703 variation is 5% life and temp
Low Temp variation @-20°C	-2.81%	0.00%	0.00% Max per JPL D-5703 variation is 5% life and temp
Radiation	0.00%	0.00%	0.00%
Aging	0.00%	0.00%	5.00% from mfr
Total	-2.81%	3.75%	5.00%
Max =	108.75%	min =	92.19%
Worst Case Maximum=	326.3	Worst Case Minimum=	276.563
Parameter			
COB	Max	Min	Source
10 V Rated freq = 1 MHz	8	2.7	Motorola data book DL126 pg 3-19 & JPL D5703 pg B-29
Aging and temp 5%	0.4	0	add 5% for life and temp JPL D 5703 pg B-29
Worst Case	8.4	2.7	pF
Parameter			
CIB	Max	Min	Source
0.5V Rated freq = 1 MHz	25	7.50	Motorola data book DL126 pg 3-19 & JPL D5703 pg B-29
Aging 5%	1.25	-0.38	add 5% for life and temp JPL D 5703 pg B-29
Worst Case	26.26	7.13	pF

(Continued)

		PART TYPE	TRANSISTOR
R PIN	2N2222A	DESCRIPTION	General Purpose NPN
IRCE P/N	ANS2N2222A	VALUE RANGE	0 - 500 mW, 0 to 600mA
Parameter	Spec @ 25 °C VCE= 10V	Source	
DC Current Gain	IC Min hFE Max hFE	MIL-SPEC data	
	0.1 50 150		
	1 75 325		
	10 100 300		
	150 100 300		
	500 30 90		
saturation	Pos Bias Neg Bias		
/ Temp @ .65%/°C	29.25	MIL-SPEC	
h Temp @ .65%/°C	39	MIL-SPEC	
saturation@ .1 mA	12.23	JPL Data % varies with current from 41 to 65mA IOM 514-E-094-94 at 150K rad	
saturation at 1 mA	11.11	JPL Data % varies with current from 41 to 65mA IOM 514-E-094-94 at 150K rad	
saturation at 10 mA and above	9.07	JPL Data % varies with current from 41 to 65% IOM 514-E-094-94 at 150mA	
total %	39 varies with current		
1mA Worst Case Max=	1.39%	.1mA Worst Case Min =	58.52% remaining @ 1OKrad and @ -20C
1mA Worst Case Max=	1.39%	.1mA Worst Case Min =	59.64% remaining @ 1OKrad and @ -20C
and >Worst Case Max=	139/I	10mA and above Worst Case	61.660A remaining @ 10Krad and @ -20C
Worst case hFE			
	IC Min hFE Max hFE		
	0.1 29.26 209		
	1 44.73 452		
	10 61.68 417		
	150 61.68 417		
	500 18.50 125		
worst Case hFE			

WORST CASE ANALYSIS PARTS DATA BASE

		PART TYPE:	Operational Amplifier
USER P/N:	LM124	DESCRIPTION:	Op Amp
SOURCE P/N:	MI L-M-38510/11005	Value Range:	V _s =±20V, Bi-Polar, up to 200K rad
Parameter	V _o = 5 to 20 V, R _L = 2 or 10 Kohms		
Open Loop Gain, A _v	Min	Max	
Rated @ 25°C	50.0	100.0	V/mV min from mil-spec, max from NSC data book
End of Life (-10% at 3 years)	-6.45	-12.91	V/mV estimate see Note 2
Radiation	-1.88	-3.76	V/mV JPL test data-various, on file
Temperature	-14.1	-24.6	V/mV MI L-SPEC
Worst Case Total	27.6	58.7	V/mV
Note 2: JPL D 5703 gives -40% for life and temp (MIL Spec gives 50% just for tmp)			
Parameter	V _{cc} = 30V		
Supply Current, I _{cc}	Min	Max	
Rated @ MIL TEMP	0.10	3.00	mA MIL-SPEC, r _{min} from NSC data book
End of Life (10% at 3 years)	0.00	0.39	mA JPL D 5703 page B-34
Radiation	0.01	0.15	mA JPL test data-various, on file
Worst Case Total	0.11	3.54	mA
Parameter	V _{cc} = 5 to 30V		
PSSR	Min	Max	
Rated @MIL TEMP	-100	100	uV/V MIL-SPEC
End of Life (10% at 15 years)	5.77	-5.77	uV/V estimate
Radiation	-3.20	-3.20	uV/V JPL test data-various, on file
Worst Case Total	-97.4	91.0	uV/V
Parameter	V _{cm} = 28V		
CMRR	Min	Max	
Rated @MIL TEMP	76	105	dB Min from MILSPEC, max from NSC data book
End of Life (10% at 15 years)	-4.39	-6.06	dB estimate
Radiation	-3.60	-4.97	dB JPL test data-various, on file
Worst Case Total	68	94	dB
Parameter	V _{cc} = 30V		
Slew Rate, SR	Min	Max	
Rated @MIL TEMP	0.10	0.10	V/us Min from MILSPEC, max not defined has to be >/= min
End of Life (10% at 15 years)	-0.01	-0.01	V/us estimate
Radiation	0.00	0.00	V/us no data
Worst Case Total	0.09	0.09	V/us

WORST CASE ANALYSIS PARTS DATA BASE

USER P/N:	LM124	PART TYPE:	Operational Amplifier
SOURCE P/N	MI L-M-38510/ I1005	DESCRIPTION:	Op Amp
		Value Range:	V_s=±20V, Bi-Polar, up to 200K rad
Parameter	RL = 10K ohms, +/-20V		
Output V Swing, Vo	Min	Max	
Rated @ MIL TEMP	27	28.5	V min from MI L-SPEC, rmax from NSC data book
End of Life (5%)	-1.35	-1.43	v estimate
Radiation	-0.05	-0.05	v JPL test data-various, on file
Worst Case Total	25.6	27.03	V
Parameter Io	At< 25 micro seconds time, only one amplifier shorted		
Short Ckt Current	Min	Max	
@MIL TEMP	-70.0	60.0	mA MIL-SPEC rein, max from data book NSC and TI

WORS CASE ANA S SPAR S D A A BASE

Project	SEAWINDS																																						
Part Number	2N2907	PART TYPE	TRANSISTOR																																				
Supplier P/N	ANS2N2907A	DESCRIPTION	General Purpose NPN																																				
		VALUE RANGE	0.500 mW, 0 to 600 mA																																				
Storage Temp	85°C	CASE																																					
Operating Temp	-20°C	CASE																																					
MTBF	5 Years																																						
Radiation	10k RAD																																						
JPL D-8545 derating																																							
Maximum Ratings	Max	Min																																					
VCEO	60	45	V																																				
VEBO	5	3.75	V																																				
ICmax	600	4s0	mA																																				
FT	217.5	184.375	MHz.																																				
Total Device Dissipation	1200	394.6	mW																																				
Junction Temperature	200	110	C																																				
These parameters are necessary to derive the SPICE models.																																							
	Max	Nom	Min																																				
hFE max	626	322.50	20.11																																				
High Current 50%	IH	500	500																																				
Low Current 50%	IL	0.1	0.1																																				
VSat	VCE(sat)	1.922	1.1564																																				
@ IC		500	0.391V																																				
VBE On	VBE	1.708V	0.442V																																				
@ VCB	Ts	1	1																																				
Storage Time	Ts	247.5	225.00																																				
Gain Bandwidth Product	Ft	217.5	200.9375																																				
Output Capacitance	COB	8.4	5.532																																				
@ VCB		10	2.664																																				
Input Capacitance	CIB	31.5	20.025																																				
@ VEB		0.5	0.5																																				
 <table border="1" style="width: 100%;"><thead><tr><th>Parameter</th><th></th><th></th><th></th></tr></thead><tbody><tr><td>VCE (sat)</td><td>Max</td><td>Min</td><td>Source</td></tr><tr><td>VCE (Sat) @ 500mA</td><td>1.600</td><td>0.400</td><td>Figure 3 of Motorola data book DL126 Rev3, pg 3-35</td></tr><tr><td>Aging</td><td>15h@3 yrs</td><td>0.310</td><td>Arrhenius equation approximation and JPL D 5703 pg B</td></tr><tr><td>Temperature</td><td></td><td>0.012</td><td>JPL D-5703 pg B-28</td></tr><tr><td>Radiation</td><td></td><td>0.000</td><td>Data from ESA suggests no appreciable change</td></tr><tr><td>Worst Case Total</td><td>1.922</td><td>0.391</td><td></td></tr><tr><td>Worst Case Max =</td><td>1.922V</td><td>Worst Case Min =</td><td>0.391V</td></tr></tbody></table>				Parameter				VCE (sat)	Max	Min	Source	VCE (Sat) @ 500mA	1.600	0.400	Figure 3 of Motorola data book DL126 Rev3, pg 3-35	Aging	15h@3 yrs	0.310	Arrhenius equation approximation and JPL D 5703 pg B	Temperature		0.012	JPL D-5703 pg B-28	Radiation		0.000	Data from ESA suggests no appreciable change	Worst Case Total	1.922	0.391		Worst Case Max =	1.922V	Worst Case Min =	0.391V				
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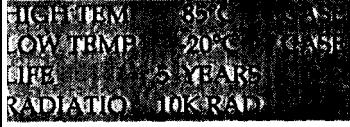
(Continued)

		PART TYPE	TRANSISTOR
USER PIN	2N2907	DESCRIPTION	General Purpose NPN
SOURCE P/N	ANS2N2907A	VALUE RANGE	10-500 mW, 0 to 600 mA
<hr/>			
Parameter			
ICBO			Source
25C rated value	0.01	μA	from MIL-SPEC
Aging 50% over 3 yrs	0.006	μA	from JPL D-5703 & arrhenius approx adjustment for life>
radiation	0.000	μA	ESA data indicates relatively no change
Temp Multiplier =2/10°C	0.120	μA	JPL D5703, multiply spec value by 2 for every 10C above
<hr/>			
Parameter			
IEBO			Source
25C rated value	0.010	μA	from MIL-SPEC
Aging 50% over 3 yrs	0.006	μA	from JPL D-5703 & arrhenius approx adjustment for life>
radiation	0.000	μA	ESA data indicates relatively no change
Temp Multiplier =2/10°C	4.800	μA	JPL D5703, multiply spec value by 2 for every 10C above
<hr/>			
T-Gain Bandwidth Product			
Spec @ 25 °C VCE= 20V f=100MHz.			
			Source
minimum	200.000	MHz.	Motorola data book DL 126 rev 3, pg 3-34
Pos Bias	Neg	Random	
High Temp variation @85°C	0.00%	3.75%	0.00% Max per JPL D-5703 variation is 5% life and temp
Low Temp variation @-20°C	-2.81%	0.00%	0.00% Max per JPL D-5703 variation is 5% life and temp
Radiation	0.00%	0.00%	0.00%
Aging	0.00%	0.00%	5.00% from mfr
Total	-2.81%	3.75%	5.00%
Max =	108.75%	min =	92.19%
Worst Case Maximum=	217.5	Worst Case Minimum=	484.375
<hr/>			
Parameter			
COB	Max	Min	Source
10 V Rated, freq = 1 MHz	8	2.7	pF Motorola data book DL126 pg 3-34 & JPL D5703 pg B-4
Aging and temp 5%	0.4	0	pF add 5% for life and temp JPL D 5703 pg B-29
Worst Case	8.4	2.7	pF
<hr/>			
Parameter			
CIB	Max	Min	Source
0.5V Rated freq = 1 MHz	30	9.00	pF Motorola data book DL126 pg 3-34 & JPL D5703 pg B-29
Aging 5%	1.5	-0.45	pF add 5% for life and temp JPL D 5703 pg B-29
Worst Case	31.5	8.5S	pF

(Continued)

		PART TYPE	TRANSISTOR
SER P/N	2N2907	DESCRIPTION	General Purpose NPN
OURCE P/N	ANS2N2907A	VALUE RANGE	0-500 mW, 0 to 600 mA
Parameter			
'E DC Current Gain	Spec @ 25 °C VCE= 10V		Source MIL-SPEC data
	IC	Min hFE	Max hFE
	0.1	75	225
	1	100	450
	10	100	300
	150	100	300
	500	30	90
variations	Pos Bias	Neg Bias	
Low Temp @ .65%/°C		29.25	MIL-SPEC
High Temp @ .65%/°C	39		MIL-SPEC
radiation @ .1 mA		8.43	JPL Data % varies with current from 41 to 65% IOM 514-E-094-94 at 150K rad
radiation at 1 mA		6.51	JPL Data % varies with current from 41 to 65% IOM 514-E-094-94 at 150K rad
radiation at 10 mA and above		3.72	JPL Data % varies with current from 41 to 65% IOM 514-E-094-94 at 150K rad
total %	39	varies with current	
.1 mA Worst Case Max=	1.39%	.1mA Worst Case Min =	62.32% remaining @ 1 OKrad and @ -20C
1mA Worst Case Max=	1.39%	1mA Worst Case Min =	64.24% remaining @ 1 OKrad and @ -20C
and > Worst Case Max=	139%	10mA and above Worst Case	67.03% remaining @ 10OKrad and @ -20C
Worst case hFE			
	IC	Min hFE	Max hFE
	0.1	46.74	313
	1	64.24	626
	10	67.03	417
	150	67.03	417 "
	500	20.11	125
Worst Case hFE			

WORST CASE ANALYSIS PARTS DATA BASE

		PART TYPE:	Operational Amplifier			
USER P/N:	LM124	DESCRIPTION:	Op Amp			
SOURCE P/N:	MIL-M-38510/11005	Value Range:	Vs=±20V, Bi-Polar, up to 200K rad			
						
		JPL D-8545				
Absolute Maximum Ratings		Rated	Derated			
Supply Voltage		*18	*14.4			
Input Voltage	Vcc	0.8Vcc				
Max Junction Temperature	175	125°C				
		Min	Max			
tV Pwr	*Power Supply Voltage	5	30 V dc			
tVin	±Input Voltage Range	-Vcc-0.3	+Vcc V dc			
DVin	Differential Input Voltage	.-	*30 V dc note 1			
in	Input Current	0.1	10 m A			
note1:the dif input voltage range shall not exceed the supply voltage range						
Parameter						
Input Offset V,V10		Min	Max			
Rated initials over mil temp	-6.13	6.20	mV MIL-SPEC			
temperature sensitivity (delta Vie/ D	-1.35	1.80	mV MIL-SPEC			
End of Life (20% at 3 years)	0.00	2.07	mV JPL D 5703 page B-34			
Radiation	0.00	1.00	mV JPL test data-various, on file			
Worst Case Total	-7.48	11.07	mV			
Parameter		Rs = 20K ohms				
Input Offset Current, I10		Min	Max			
Rated initials over miltemp	-55.31	30.00	nA MIL-SPEC			
temperature sensitivity (delta lio/ De	-31.50	42.00	nA MIL-SPEC			
End of Life (10% at 3 years)	0.00	9.30	nA JPL D 5703 page B-34			
Radiation	-6.72	4.60	nA JPL test data-various, on file			
Worst Case Total	-93.53	85.90	nA			
Parameter		Rs = 20K				
Input Bias Current, IB		Min	Max			
Rated @MIL TEMP	-234.38	-1.00	nA MIL-SPEC			
End of Life (10% at 3 years)	0.00	0.13	nA JPL D 5703 page B-34			
Radiation	-43.06	-0.03	nA JPL test data-various, on file			
Worst Case Total	-277.43	-0.90	nA			

V₀

LM124 radiation data

V ₀	dB	O K	20K	50K	60K	100K	200K	400K
test numb	serial num							
12429	min	2.85E+01		2.84E+01		2.84E+01		
	max	2.86E+01		2.85E+01		2.85E+01		
	mean	2.85E+01		2.85E+01		2.85E+01		
	mean	2.85E+01		2.85E+01		2.85E+01		
		2.85E+01				2.85E+01		
			0.05				0.05	
			28.375				28.325	
								0.05

Vo

500K 1M